IN THE CLAIMS

1. A method to form an air gap interconnect structure comprising:

   a. forming a multi-layer interconnect adjacent a substrate layer, the interconnect comprising conductive layers positioned in at least two conductive vertical series, the conductive vertical series isolated from each other by sacrificial dielectric material;

   b. forming a protective layer adjacent the interconnect;

   c. patterning the protective layer to expose portions of the sacrificial dielectric material;

   d. decomposing portions of the sacrificial dielectric material to form sacrificial dielectric decomposition; and

   e. removing portions of the sacrificial dielectric decomposition to form air gaps between the conductive layers.

2. The method of claim 1 wherein forming a multi-layer interconnect comprises

   a. forming a first layer of sacrificial dielectric material, forming trenches in the first layer, and filling the trenches with conductive material to form at least two conductive layers isolated from each other by sacrificial dielectric material; and

   b. forming a second layer of sacrificial dielectric material adjacent the at least two conductive layers and first layer, forming trenches in the second layer in substantial vertical alignment with the trenches of the first layer, and filling the trenches with conductive material to form at least two additional conductive layers isolated from each other by sacrificial dielectric material.

3. The method of claim 1 wherein forming a multi-layer interconnect comprises forming between about 2 and about 6 conductive layers in each conductive vertical series.

4. The method of claim 2 wherein decomposing comprises decomposing substantially all of the sacrificial dielectric material between each of the vertical series.

5. The method of claim 4 wherein removing comprises removing substantially all of the sacrificial dielectric material between each of the vertical series.

6. The method of claim 1 wherein decomposing comprises introducing a chemical agent comprising hydrofluoric acid.

7. The method of claim 1 wherein removing comprises introducing water.

8. The method of claim 1 wherein removing comprises introducing a carrier plasma.

9. The method of claim 1 wherein conductive layers comprise copper.

10. The method of claim 1 wherein the sacrificial dielectric material comprises a material selected from the group consisting of silicon dioxide, silicon oxynitride, and silicon oxyfluoride.

11. The method of claim 1 wherein the protective layer comprises silicon carbide.

12. The method of claim 1 further comprising forming vertical support structures peripheral to the conductive vertical series.

13. The method of claim 12 further comprising forming a first capping layer to contact the vertical support structures and surfaces of the most highly positioned conductive layers within each conductive vertical series.

14. The method of claim 13 further comprising forming a second capping layer adjacent the first capping layer.

15. The method of claim 14 further comprising forming a third capping layer adjacent the second capping layer.

16. The method of claim 15 further comprising forming a contact structure through the protective layer and first, second, and third capping layers to contact an underlying conductive layer.

17. The method of claim 13 wherein the first capping layer comprises polyimide or a benzocyclobutene-based polymer.

18. The method of claim 14 wherein the second capping layer comprises a material selected from the group consisting of silicon dioxide, silicon nitride, and silicon oxynitride.

19. The method of claim 15 wherein the third capping layer comprises polyimide or a benzocyclobutene-based polymer.

20. The method of claim 16 wherein the contact structure metallic C4 structure.

21. An air gap interconnect structure comprising:

a. a substrate layer; and

b. at least two conductive vertical series adjacent the substrate layer, each conductive vertical series comprising a plurality of conductive layers, wherein the conductive vertical series are isolated from each other by air gaps defined by side walls of the conductive vertical series.

22. The structure of claim 21, further comprising:

a. vertical support structures peripheral to the conductive vertical series; and

b. a capping layer adjacent to and above upper surfaces of the vertical support structures and the conductive vertical series.

23. The structure of claim 22 wherein each conductive vertical series comprises between about 2 and about 6 conductive layers.

24. The structure of claim 22 wherein the vertical support structures peripheral to the conductive vertical series protrude slightly more from the plane of the substrate layer than the uppermost conductive layer in the conductive vertical series.

25. The structure of claim 22 further comprising a contact structure extending through the capping layer to contact an underlying conductive layer of a conductive vertical series.